washing sand and débris over them in some parts of the city, and a few cellars were flooded.

STORM AT MAZUMA, NEV.

By H. F. ALPS, Section Director.

One of the most disastrous floods ever known in Nevada occurred in the Seven Troughs and Mazuma mining districts about 5 p. m., July 18, washing away all the frail buildings at Mazuma and killing nine persons, as well as seriously injuring several others. Water to a depth of 15 to 20 feet rushed down the canyon upon the mining camp at Mazuma without warning, and carried the wreckage of frame buildings to the flat below, a distance of over a mile.

The canyon is wide at Seven Troughs, and damage there was confined to the loss of a few buildings in the business portion. The water struck the cyanide plant of the Coalition Mining Co. and destroyed the building, taking the large concrete vault down the canyon and breaking it into fragments.

Mazuma is about 2 miles below Seven Troughs in a narrow canyon with precipitous sides. Here the flood waters left only a hotel and a store.

The flood came without warning, as it was not raining at the camps at the time, although a light sprinkle had fallen a few minutes before. The basin in the mountains where the heavy precipitation occurred covers an area of about 4 square miles. The heavy downpour was seen by two mining engineers who were observing the thunderstorm from the Coalition office at Seven Troughs. When the danger of the flood was realized, they endeavored to notify Mazuma, but the wires had been put out of service by lightning. Had it been possible to give warning of the flood a few minutes before it reached Mazuma there would have been no loss of life, as a climb of a few rods up the sides of the canyon would have been sufficient to place the people above the crest of the water. Three small canyons unite with the Seven Troughs canyon, and when heavy thunderstorms occur in the catch-basins of these canyons, the conditions are very favorable for floods at Mazuma where the canyon is narrow.

RECENT STORMS AT MURRAY, UTAH.

By R. C. TOWLER.

The rains at Murray, Utah, during the latter part of July were unusually heavy for this month. Early in July but little rain fell, but from July 18 until the close of the month storms were frequent and heavy.

Rain on July 19 was especially heavy between the hours of 10 a. m. and noon, followed by a more steady fall until 3 p. m., amounting to something over 1 inch.

On July 28 another heavy storm occurred between 4 and 6 p. m., and still another on the evening of July 31, accompanied by considerable thunder and lightning.

The effect of the storms in general was good for beets, corn, tomatoes, alfalfa, potatoes, and orchards. Some damage was done, however, in the lower bottoms, to grain fields, many of which, ready for harvest, were laid flat. The rains in the nearby canyons was heavy and the flow of the streams from them was thereby strengthened, so that the farmers in this vicinity are fearing no shortage of water for irrigation during the rest of the season.

THE RELATION BETWEEN LIGHT PRECIPITATION AND "ALKALI."

By R. A. HART, United States Drainage Engineer.

The baneful effects of so-called "alkali" upon agriculture and horticulture in the arid section of the United States have become so widespread and intense as to present a serious problem in the future development of the West. Confined at first to recognized deserts, or to minor spots which occasioned indifferent wonder, rather than real interest, accumulation of alkaline salts are now becoming so general throughout the irrigated valleys as to cause alarm which is, indeed, well founded.

It is a fact that wherever irrigation has been practiced for any considerable length of time, lands formerly highly productive are now showing injury to a greater or less extent. In some instances there is merely a decrease in the general crop returns, or yields are spotted, with portions of a given tract producing as well as ever, while other portions are practically barren; but in many instances whole farms and series of farms have become unproductive and have been abandoned. Broadly speaking, there is not a valley in the West in which the injury has not been felt, and in some of these a large portion of the lands formerly cultivated are now idle or used only for wild pasture. In nearly every case, the accumulation of an excess of alkaline salts in the surface soil played an important part in the destruction. The fact that such salts were responsible for the injury wrought has nearly always been recognized by agriculturists, but they have rarely stopped to consider why this should be so, or what means might be taken to prevent injury, or to reclaim injured lands. As a result abandonment took place and new tracts were put under cultivation. This method served while there was an abundance of raw land to be had, although the cost of taking up new land was often higher than the reclamation of the old would have been, but these new lands were, in turn, subject to the same difficulty, so that now, with the opportunity for expansion practically gone, it is necessary that the second reclamation of the desert be effected, and such work in that direction is now being prosecuted. Were such reclamation not possible, permanent agriculture in a major portion of the irrigated region would be out of the question, so that this work becomes an important factor in the advancement of that region.

Water plays an important rôle in the transformation which has been noted, and it is interesting to make a study of its connection, both as rainfall and as irrigation water. It seems to be the popular notion that the alkaline salts are inherently associated only with arid soils, but this is a misconception. As a matter of fact alkaline salts are products of rock materials which, in the early stages of the earth's history, were rather uniformly distributed throughout the crust. The disassociation of the rock material was brought about by the action of heat, cold, ice, water, air, wind, vegetation, and numerous gases and solutions, and the alkaline salts were liberated. Being soluble in water they were readily transported about by its movement with the result that, as time wore on, soils in regions of heavy rainfall were washed almost free by a leaching action, and the salts found their way to the sea, rendering it saline. In the arid section, on the other hand, although the elements were active in disassociating the rock material, there was

so little rainfall that the transportation was extremely limited and as a result the salts were deposited in the soils of the valleys, or in extreme cases in basins or lakes having no outlet. Thus the valley soils came to have an excess of alkaline salts so that only the hardier plants may live, while the basins and sinks become depositories for large accumulations of salts and the lakes become very saline, indeed. The Great Salt Lake, whose waters are seven times as salty as the sea, is a good example of this fact.

The precipitation, while insufficient to sweeten the valley soils, is generally copious enough to leach out the salts in the immediate surface and carry them downward by percolation to such a depth that sagebrush, wild grasses, etc., may thrive to a limited extent. Evaporation in the arid section is so high, however, that there is very little percolation, with the result that the ground-water table was usually found at a great depth when examinations were first made. The downward movement of the percolating water is very slow, since the soils have poor natural drainage and, owing to the lack of vegetation, few noncapillary spaces have been formed. Then, too, the presence of more pervious strata causes the lateral movement of water.

The chief element lacking, in the successful cultivation of the soils of the arid regions, is water, and this may usually be supplied artificially by irrigation. Most of the plant foods are formed from salts having many characteristics in common with the harmful salts and are released from the rock material and transported in much the same way, so that the arid soils are inherently rich in such foods, and there is besides a continual supply which almost makes up for that used in plant production, and which renders such soils almost permanently fertile.

It is practically impossible to supply just the right amount of water in irrigating, so it is both necessary and advisable to use a slight excess. The natural tendency, born of a fear of drought and the human desire to take all that may be had, leads, however, to the use of a great excess which not only has the direct result of decreasing the yield, but as we shall see, has the indirect result of actually eliminating production altogether and rendering the land useless.

A portion of the excess water is lost by evaporation and, unless irrigation is carefully practiced, by actual surface waste. The remainder of the excess moves downward through the soil by percolation, and it is this movement which leaches out the alkaline salts from the root zone of the soil and makes agriculture possible. But it is this percolating excess which, if allowed to go on, will eventually result in destruction. This is occasioned by an actual filling up of the ground water reservoir and a consequent rise of the water table.

It is a well-known fact that soils are saturated several feet above the free water level, due to the action of capillary attraction, and it is found that the alkaline solution is concentrated near the upper limit of saturation, so that in the upward movement of the water table, the concentrated alkaline solution precedes it by a few feet. It has also been observed that pervious strata usually hold considerable amounts of salts, and these accumulations are assimilated during the upward movement. It can be readily seen, therefore, that when the ground-water table reaches a plane within the capillary distance of the ground surface, evaporation of the concentrated solution will deposit the salts at and near the surface, resulting in the death of plants.

The application of irrigation water will not now carry down the salts as in the first instance, as there is no escape for the percolating water. The result of such a treatment is merely to redissolve the salts, which are then drawn back into the soil to reappear by subsequent evaporation.

The proximity of the ground-water table is, in itself, disastrous and it is often difficult to say whether plants are killed by one or both agents, but it is known that an excess of salts is injurious and it is that phase of the question which is now under consideration.

As was pointed out in the first paragraphs, it is imperative that something be done to remedy the existing evil and to prevent future injury. It is fortunate that the remedy is simple and may be readily, and in most cases, economically applied. It is especially fortunate that both the water and the alkali injury may be cured and prevented by the same treatment. Indeed, when the water question is solved, the alkali question is solved as a matter of course.

It is necessary only to lower the ground-water table to such a depth that capillary attraction can not raise water and alkali salts near enough the surface to do damage, and to repeat the original process of leaching out the alkaline salts by the use of an excess of irrigation water, after which it is advisable to use a sane amount of irrigation water, not that there is any further fear of injury, but that there is need for the water, so worse than wasted, on other lands for the production of more crops.

Good underdrainage is the only cure for the difficulty, and its effectiveness is best demonstrated by the vast operations now being conducted. The second reclamation of the desert is now at hand, and a few years will undoubtedly see the broad expanses of overirrigated and alkaline lands transformed again into gardens and fields.